The Organic Refractory Material in the Diffuse Interstellar Medium: Mid-Infrared Spectroscopic Constraints

Yvonne J. Pendleton, Louis J. Allamandola

An analysis was made of the 4000- to 1000-cm^{-1} (2.5- to 10-micron) region of the spectrum of diffuse interstellar medium (DISM) dust compared with the spectra of 13 laboratory-produced chemical candidates that serve as analogs to the interstellar material. Results indicate that the organic refractory material in the DISM is predominantly hydrocarbon in nature, possessing little nitrogen or oxygen, with the carbon distributed between the aromatic and aliphatic forms. Long alkane chains H_3C-$(CH_2)_n$- with n much greater than 4 or 5 are not major constituents of this material.

Spectral analysis of the DISM allows us to place significant constraints on the likelihood of the proposed materials to be present in it. The spectra of candidate materials are evaluated using four spectral characteristics based on the interstellar data. Comparisons to laboratory analogs indicate that the DISM organic material resembles plasma-processed pure hydrocarbon residues much more so than energetically processed ice residues, which were previously thought to be relevant analogs. This result is consistent with a birth site for the carrier of the 3.4-micron band in the outflow region of evolved carbon stars, rather than in the icy mantles of dense cloud dust.

The organic signatures of extragalactic dust, carbonaceous chondritic material, and E. coli bacteria have also been compared because they have been discussed in the literature as relevant to the DISM. The organic material extracted from the Murchison carbonaceous meteorite and the spectrum of E. coli bacteria reveals spectral features in the 5–10 micron region that are absent in the DISM. Although the presence of unaltered circumstellar components in the Murchison meteorite has been established through several lines of evidence, it is unclear whether or not the aliphatic component that gives rise to the 3.4-micron band is in that category. With respect to the complete 2–10 micron wavelength region, no spectral evidence exists for a biological origin of the 3.4-micron interstellar absorption band. The similarity of the aliphatic CH stretch region of dust from our own galaxy to that of distant galaxies suggests that the organic component of the interstellar medium is widespread and may be an important universal reservoir of prebiotic organic carbon.

Point of Contact: Y. Pendleton
(650) 604-4391
ypendleton@mail.arc.nasa.gov